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A DYNAMIC PRESSURE GENERATOR FOR CHECKING COMPLETE PRESSURE SENSING SYSTEMS INSTALLED ON AN AIRPLANE

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16. Abstract

A portable dynamic pressure generator, how it operates, and a test setup on an airplane are described. The generator is capable of providing a sinusoidal pressure having a peak-to-peak amplitude of 3.5 N/cm^2 (5 psi) at frequencies ranging from 100 hertz to 200 hertz. A typical power spectral density plot of data from actual dynamic pressure fluctuation tests within the air inlet of the YF-12 airplane is presented.

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INTRODUCTION

Dynamic pressure fluctuations in jet engine inlets have been identified as the cause of many unexplained engine instabilities (refs. 1 and 2), and can seriously affect the operation of a jet engine. High frequency response pressure sensing systems are installed to measure such fluctuations in flight, but are subject to many sources of error and thus need to be checked with a fluctuating pressure. This discovery has spurred the development of a dynamic pressure measuring system for testing transducers, signal conditioning, modulation, and recording systems as well as playback and analysis systems. With all of these elements in the data chain, the quality of the final analyzed result can be questionable, for each element can distort or modify the end product.

To insure that such distortions have not occurred in either the pneumatic tubing of a probe or in the electronics of the data system, an end-to-end check must be made. In this check a known pressure fluctuation has to be applied to an installed pressure sensing probe on an airplane so the output can be compared with the original input. This procedure requires a portable dynamic pressure generator which produces a signal of significant amplitude at various frequencies in the range of interest. This generator must be easy to set up and small enough to fit into the cramped quarters of aircraft inlets. It must also meet safety standards if it is to be used in an aircraft where fuel is present. Several dynamic pressure generators have been developed for laboratory use (refs. 3 and 4), but none meets the criteria for use on an aircraft.

This report describes a portable dynamic pressure generator which has been developed for use on the YF-12 aircraft to make in-place evaluations of data quality. An end-to-end analysis of the aircraft pressure measurement system was made by comparing power spectral density plots of the output of the installed pressure system with the output of a reference transducer in the pressure generator equipment.

DESCRIPTION OF DYNAMIC PRESSURE GENERATOR

The dynamic pressure generator has three principal components: a fluctuating pressure generator, a pistol-grip unit for applying the test pressure to a sensing port on an aircraft, and an electronic amplifier for increasing the strength of the signal from the reference pressure transducer within the pistol-grip unit. A photograph of the equipment is shown in figure 1, and a schematic diagram of a typical test setup is shown in figure 2.

The pistol-grip unit, shown in figure 3, is a compact unit consisting of a nozzle and a Statham reference transducer in an aluminum body, connected by a T-shaped passage. In use, the nozzle is held against a pressure sensing port of the aircraft. The geometry is such that the aircraft transducer and the reference pressure transducer are both connected to the passage with approximately equal volume. The handle of the unit is angled as shown to provide adequate hand clearance when the unit is pressed against a port. An electrical cable carries the reference pressure signal to the amplifier, and a tube carries the fluctuating pressure from the dynamic pressure generator. The tube length is no greater than 3.047 meters (10 feet) to avoid excessive attentuation of the dynamic pressure signal.

The fluctuating generator has a motor-driven shaft with a round disc on the end, as shown in figure 4. The disc was tilted slightly on the shaft to modulate the incoming air. As the air comes into the input tube, the area that it has to expand in determines the amount of pressure that is put out. The farther the plate is from the input port, the less the pressure output will be. As the distance between the plate and the port becomes smaller, the output pressure increases because the input air is compressed into a smaller area, creating a sine wave output.

TEST PROCEDURE AND DATA PROCESSING

The procedure used to check the pressure sensing system installed in the inlet duct of the YF-12 airplane is illustrated in figure 2. Air pressure at approximately 3.5 N/cm^2 (5 psi) was supplied by a regulated pressure source which was connected to the fluctuating pressure generator. The desired frequency was set by adjusting the potentiometer on the fluctuating pressure generator. For these tests, nominal frequencies of 100 hertz and 200 hertz were used.

The pistol-grip unit, which was connected to the fluctuating pressure generator, was applied to each port of the aircraft pressure sensing system. The pressure transducer in the pistol-grip unit was connected to an oscilloscope. The degree of distortion of the pressure wave shown on the oscilloscope provided a measure of the quality of the connection with the pressure port. When the nozzle made a good seal with the pressure port, an undistorted sine wave appeared on the scope and the recorder was turned on. The signal from the transducer system being tested was recorded at the same time on the same recording system as the reference transducer but on a different track. Figure 5 shows how the pistol-grip unit was applied to a typical static pressure port on the cowl.

TEST RESULTS

The data on the tape were processed on an analog computer and printed out as shown in figure 6. The amplitude of the reference pressure transducer appears larger than that of the airplane transducer because the reference transducer signal was reinforced before it was recorded and the airplane transducer was not. The reference transducer and the airplane transducer both show approximately the same pressure fluctuation amplitude. Both transducer records show distorted waveforms which could be due, in part, to an unsteady seal on the port. However, the more severe distortion of the airplane transducer wave was caused by effects of the airplane data recording system.

Figures 7(a) and 7(b) are typical power spectral density plots for the airplane transducer and the reference transducer at nominal input frequencies of 100 hertz and 200 hertz, respectively. The frequencies on the plots are not at exactly the nominal frequencies, because of the inaccuracy of the setting on the fluctuating generator, but are within 5 percent of the nominal input. The frequency peaks, which represent a concentration of energy at the nominal input frequencies, show close agreement. Most of the airplane transducer data obtained were within 30 percent of the reference transducer data, which showed that the pressure measuring system was satisfactory.

CONCLUDING REMARKS

A simple portable dynamic pressure generator has been developed for in-place end-to-end evaluation of the quality of dynamic data produced by the dynamic pressure data system of the YF-12 aircraft. The frequency and amplitude of the data, as well as statistical functions such as power spectral density, have been verified.

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National Aeronautics and Space Administration
Edwards, Calif., September 3, 1974

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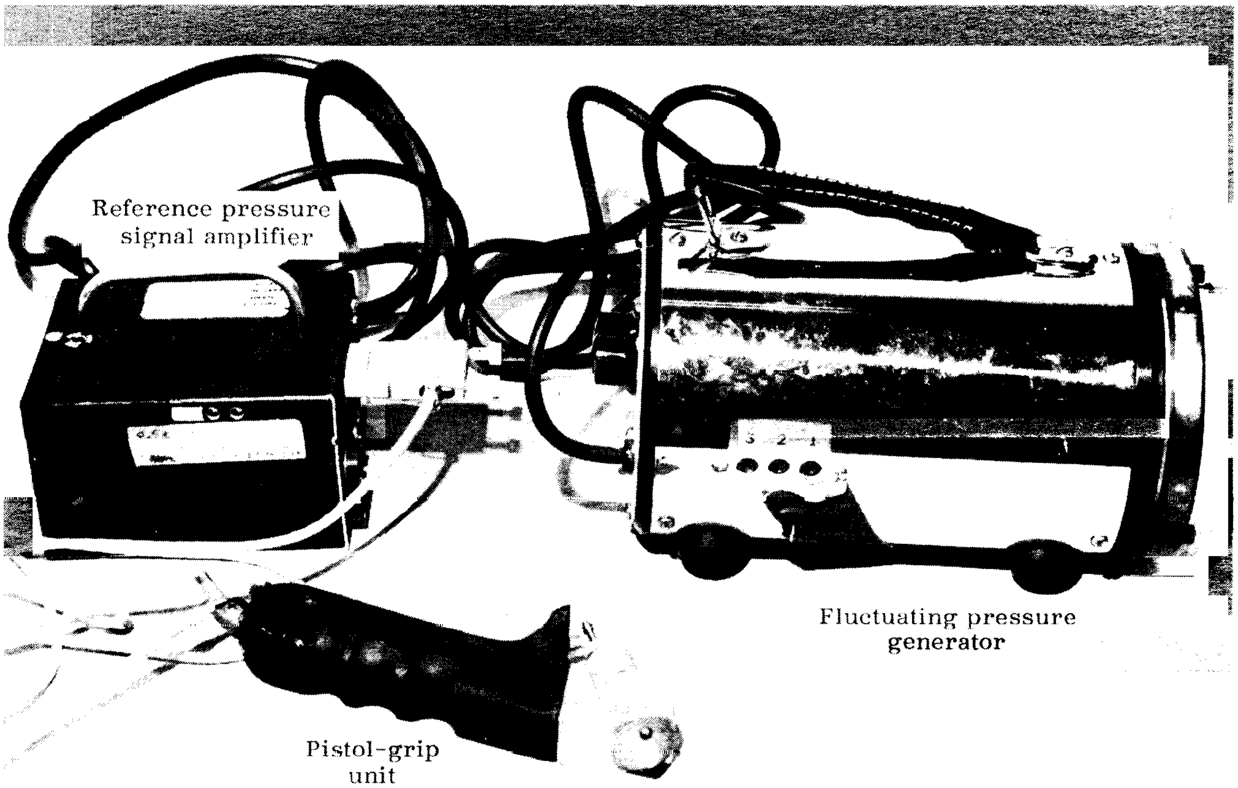


Figure 1. Portable dynamic pressure generator. E-27580

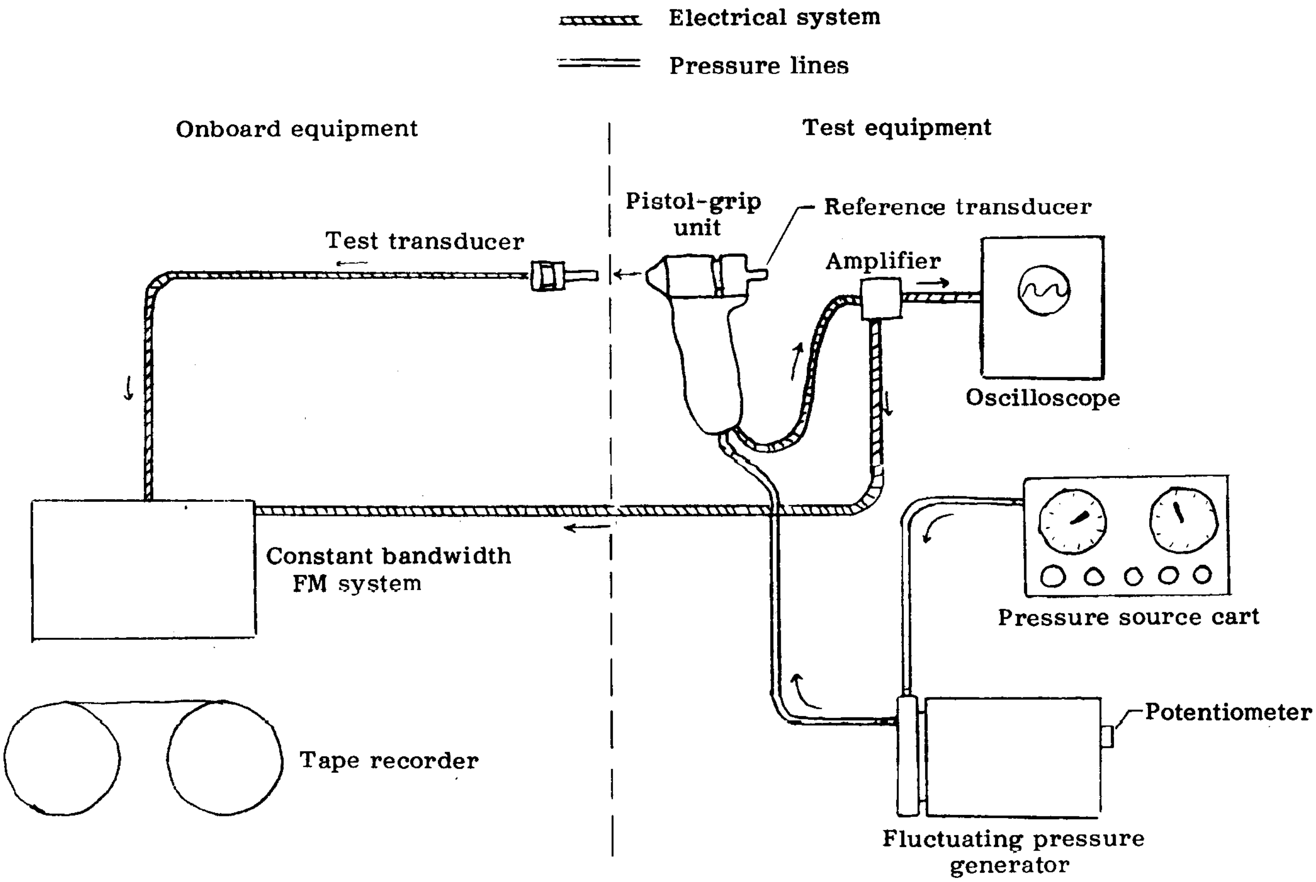


Figure 2. Setup for dynamic pressure test.

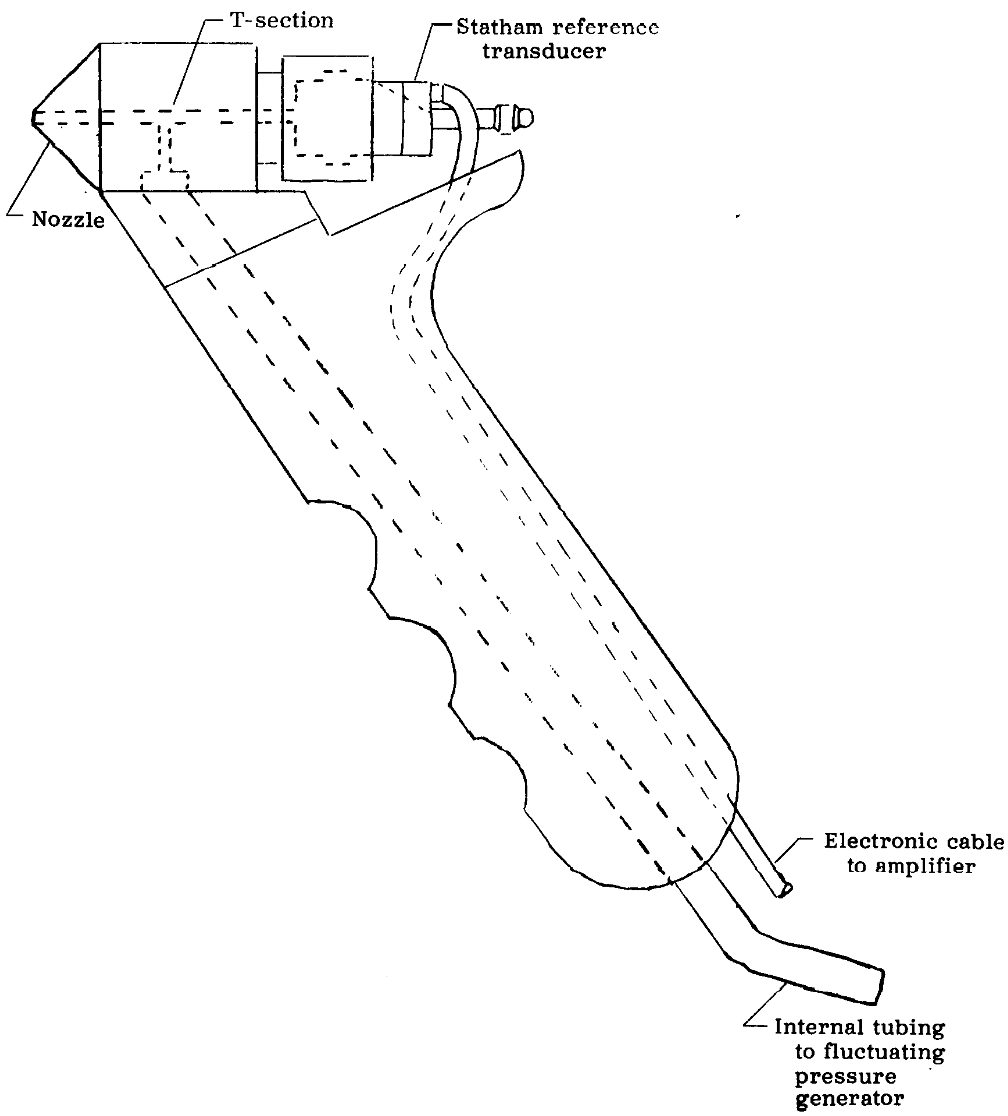


Figure 3. Pistol-grip unit.

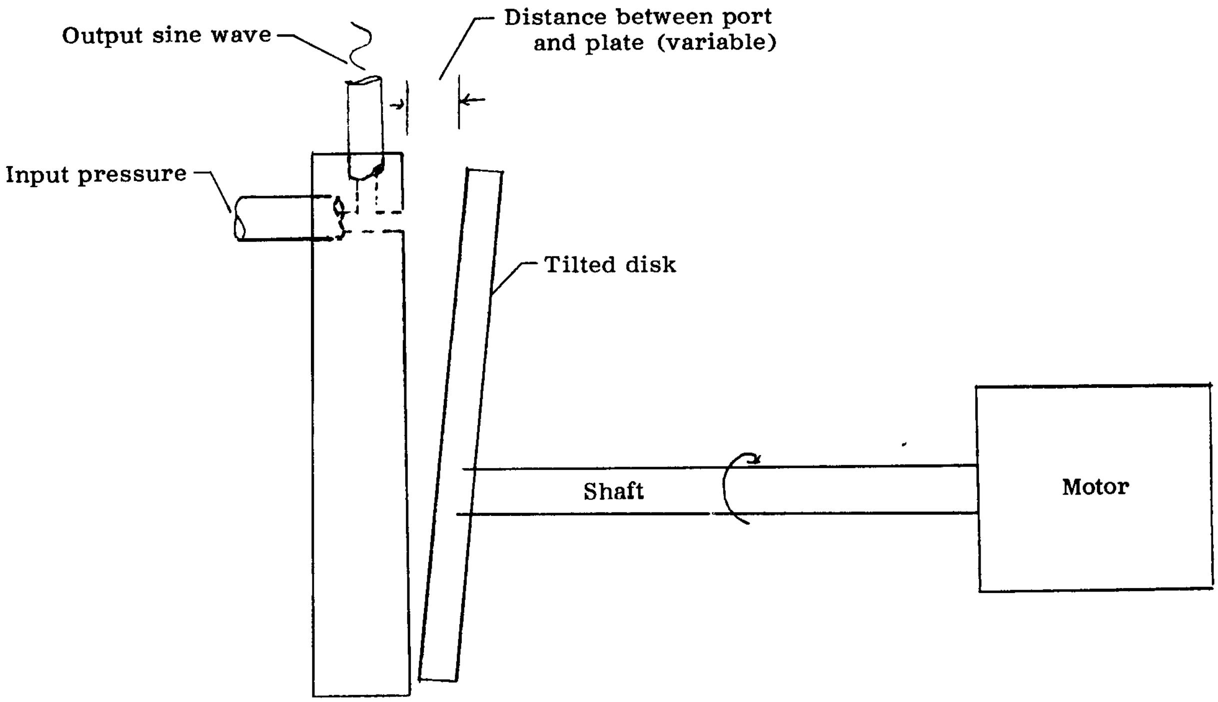


Figure 4. Fluctuating pressure generator schematic.

Figure 5. Application of the pistol-grip unit to a test transducer. E-27578

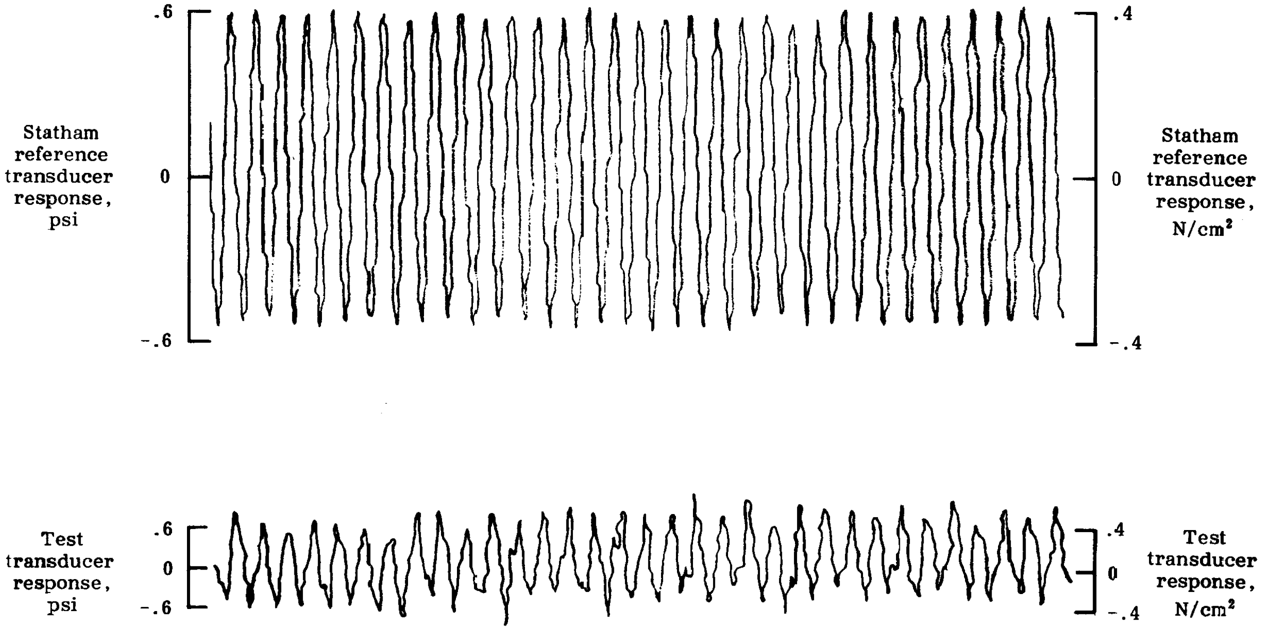
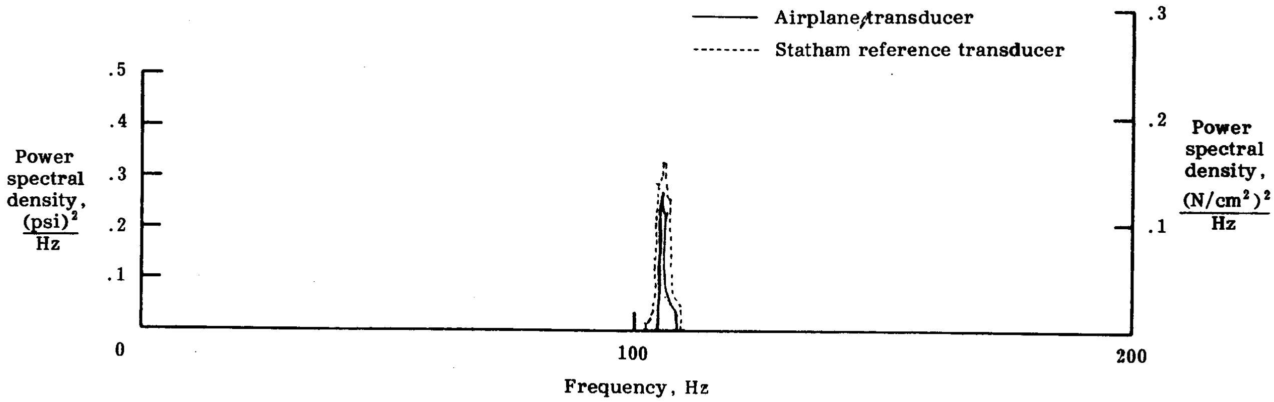
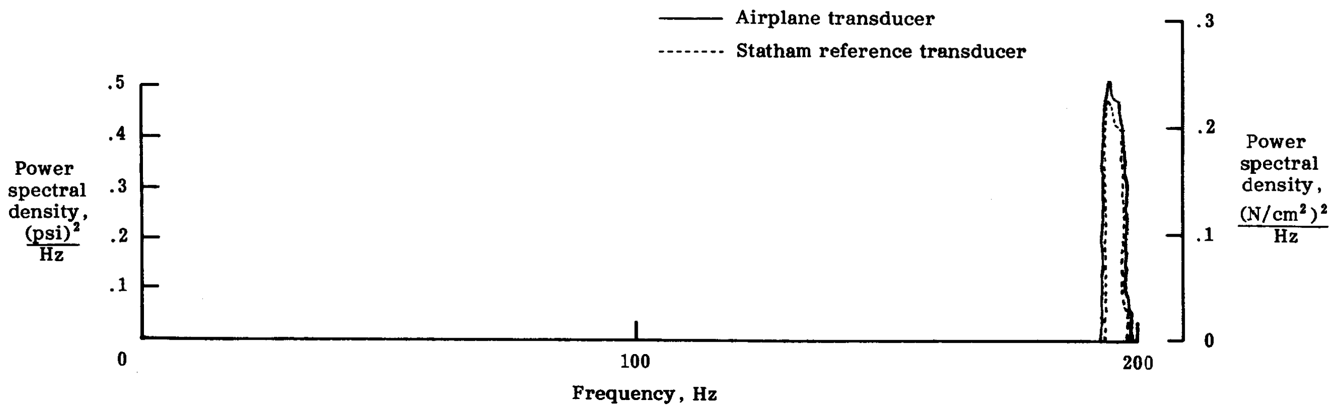


Figure 6. Analog computer printout of recorded data.



(a) 100-hertz nominal input frequency.



(b) 200-hertz nominal input frequency.

Figure 7. Frequency analysis comparison of airplane transducer and reference pressure transducer.